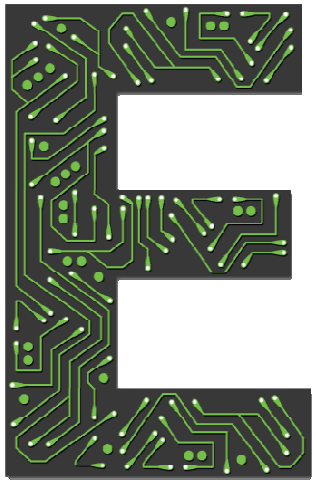
eSTUDENT
NETWORK OF eXCELLENCE



ELEKTROBOJ

Radionica: Glazbena olovka – od olovke do jednostavnog glazbala

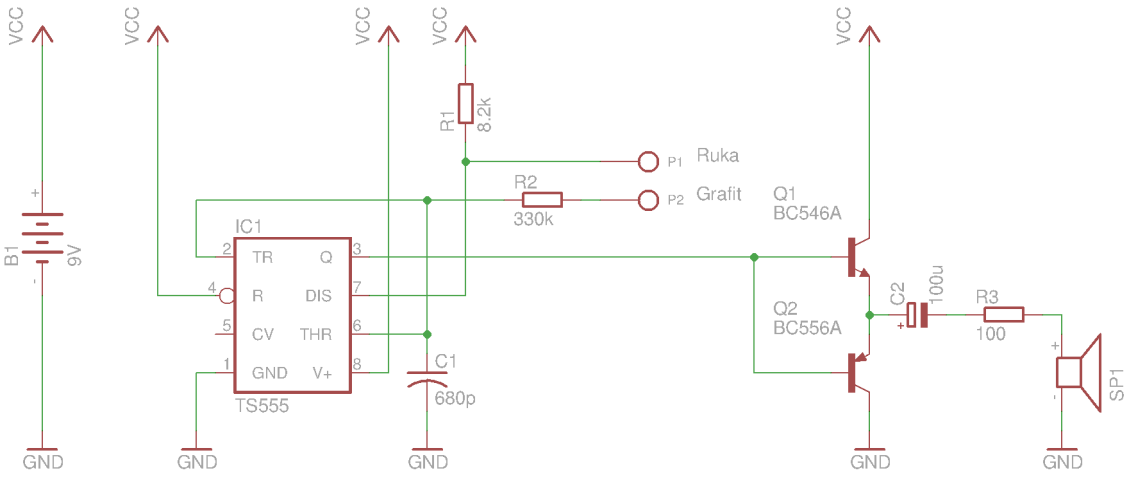
KRATKE UPUTE

Davor Cihlar

Popis komponenti:

Molimo Vas da pregledate radno mjesto i stavite kvačicu kraj onih komponenata koje imate pred sobom. Ukoliko Vam nedostaje nešto od navedenoga, odmah recite.

Naziv:	**Količina:**	**Potvrda:**
Baterija 9V	1	
Konektor za 9V bateriju	1	
Integrirani krug TS555	1	
Podnožje za TS555	1	
Tranzistor BC546	1	
Tranzistor BC556	1	
Otpornik 8.2kΩ	1	
Otpornik 330kΩ	1	
Otpornik 100Ω	1	
Elektrolitski kondenzator 100µF	1	
Keramički kondenzator 680pF	1	
Zvučnik	1	
Mala pločica za lemljenje	1	
Žice za spajanje		
Lemilica	1	
Tinol	1	



Slika 1. Shema

Proučite detaljno shemu! Ukoliko vam nešto nije jasno pozovite nekoga od nas i zatražite pomoć i dodatna pojašnjenja.

OBJAŠNJENE RADA:

Oscilator:
Srce sklopa je oscilator koji mijenja svoju frekvenciju u ovisnosti o otporniku spojenom na priključke P1 i P2 (nazovimo ga R_{EXT}). R_{EXT} ovisi o seriji otpora grafita u olovci (nekoliko oma – zanemarivo), čovjeka (oko 200kΩ) i crteža (do 1MΩ na nekoliko centimetara). Crtež je jedina varijabilna vrijednost i o njemu će u konačnosti ovisiti frekvencija.

Oscilator je temeljen na vremenskom integriranom krugu TS555 (IC1) koji periodički puni i prazni kondenzator C1. C1 se puni preko serije otpornika R1, R_{EXT} i R2, a prazni preko serije otpornika R_{EXT} i R2. C1 se sporije puni zbog većeg otpora i kako bi trajanje punjenja bilo što bliže trajanju pražnjenja (*duty cycle* ≈ 50%) otpornik R1 mora biti što manji. Proizvoljno je odabran nekoliko reda veličine manji otpor od 8.2kΩ.
Formula za frekvenciju oscilatora je sljedeća:

$$f = \frac{1}{\ln(2)\cdot(R1+2(R2+R_{EXT}))\cdot C1}$$

Uvrštavanjem vrijednosti otpornika u formulu za frekvencije 20Hz i 20kHz možemo zaključiti da bi nam za C1 pasao kondenzator od oko 680pF. R2 ograničava maksimalnu frekvenciju (pri R_{EXT} = 0Ω) sa svojih 330kΩ na oko 20kHz.

Pojačalo:
Za maksimalnu snagu na zvučniku od 8Ω, 0.2W je potrebna struja od oko 160mA:

$$P = I^2 \cdot R \rightarrow I = \sqrt{\frac{P}{R}}$$

No TS555 na izlazu može dati svega desetak miliampera. Stoga je potrebno ubaciti pojačalo između zvučnika i vremenskog sklopa.
Pojačalo s dva tranzistora prikazano na shemi (Q1 i Q2) je jedno od najjednostavnijih. Sastoji se od pozitivnog i negativnog slijedila napona i stoga mu je naponsko pojačanje ×1.
Korišteni su nešto slabiji tranzistori kako bi sklop bio jeftiniji i kako bi baterija duže trajala – nije

potrebna maksimalna glasnoća. U seriju sa zvučnikom je otpornik (R3) od 100Ω kako bi ograničio struju kroz zvučnik i smanjio opterećenje na tranzistorima koji ne mogu dati više od 100mA.

$$I = \frac{U}{R} = \frac{U_{BAT} - U_{BE}}{R3 + R_{SP1}} = \frac{9\text{V} - 0.7\text{V}}{100\Omega + 8\Omega} = 78\text{mA}$$

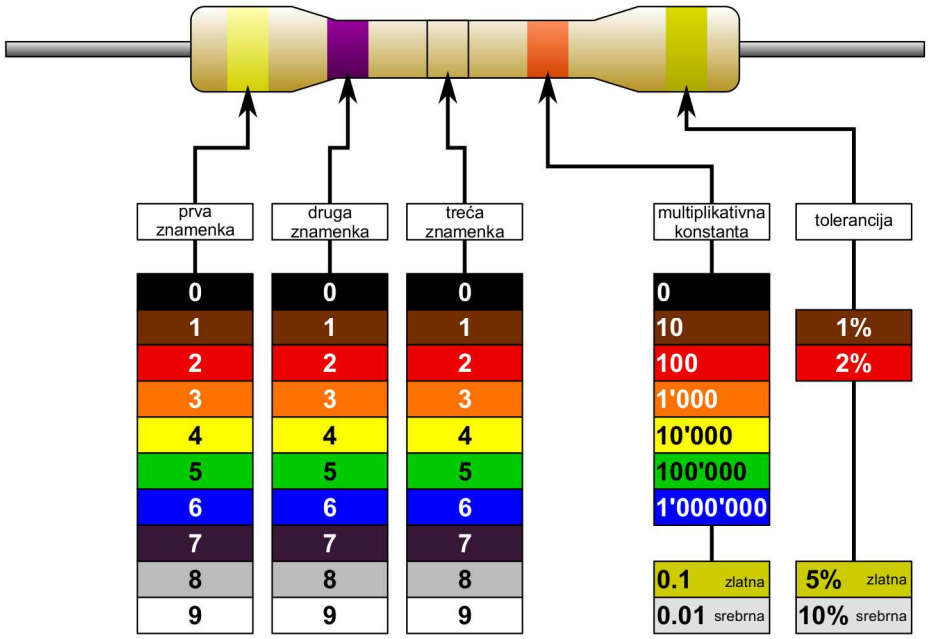
Osim otpornika u seriji sa zvučnikom se nalazi i elektrolitski kondenzator (C2). Njegova uloga je zaštita zvučnika od istosmjerne komponente iz pojačala. Kapacitet mora biti što veći kako bi impedancija pri 20Hz bila što manja.

SAVJETI:

- Prije samog lemljenja komponenata na pločicu, pregledajte shemu i napravite okvirni plan, tj. raspored komponenti na pločici. Time ćete si uštedjeti puno vremena i smanjiti mogućnost pogreške.
- Nikako nemojte stavljati žice preko integriranog kruga jer ga onda više neće biti moguće lako zamijeniti.

U dodatku se nalaze ključne stranice iz tehničkih dokumentacija svih poluvodičkih komponenti. Više informacija možete pronaći na sljedećim poveznicama:

- http://tinyurl.com/TS555N
- http://tinyurl.com/BC546A
- http://tinyurl.com/BC556A



Slika 2: Legenda boja otpornika

TS555

Low power single CMOS timer

Features

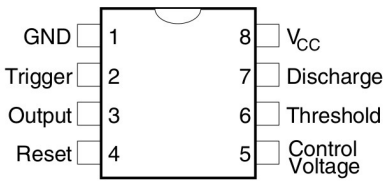
- Very low power consumption:
  110 µA typ at V_{CC} = 5 V
  90 µa typ at V_{CC} = 3 V
- High maximum astable frequency of 2.7 MHz
- Pin-to-pin functionally-compatible with bipolar NE555
- Wide voltage range: +2 V to +16 V
- Supply current spikes reduced during output transitions
- High input impedance: 10^{12} Ω
- Output compatible with TTL, CMOS and logic MOS

N
DIP8
(Plastic package)

D
SO8
(Plastic micropackage)

P
TSSOP8
(Thin shrink small outline package)

Pin connections
(top view)



Description

The TS555 is a single CMOS timer with a very low consumption:
($I_{cc(TYP)}$ TS555 = 110 µA at V_{CC} = +5 V versus $I_{cc(TYP)}$ NE555 = 3 mA),
and high frequency:
($f_{f(max.)}$ TS555 = 2.7 MHz versus $f_{(max)}$ NE555 = 0.1 MHz).

Timing remains accurate in both monostable and astable mode.

The TS555 provides reduced supply current spikes during output transitions, which enable the use of lower decoupling capacitors compared to those required by bipolar NE555.

With the high input impedance ($10^{12}\Omega$), timing capacitors can also be minimized.

4.2 Astable operation

When the circuit is connected as shown in *Figure 6* (pins 2 and 6 connected) it triggers itself and runs as a multi-vibrator. The external capacitor charges through R_A and R_B and discharges through R_B only. Therefore, the duty cycle may be precisely set by the ratio of these two resistors.

In the astable mode of operation, C charges and discharges between 1/3 V_{CC} and 2/3 V_{CC}. As in the triggered mode, the charge and discharge times, and therefore frequency, are independent of the supply voltage.

Figure 6. Application schematic

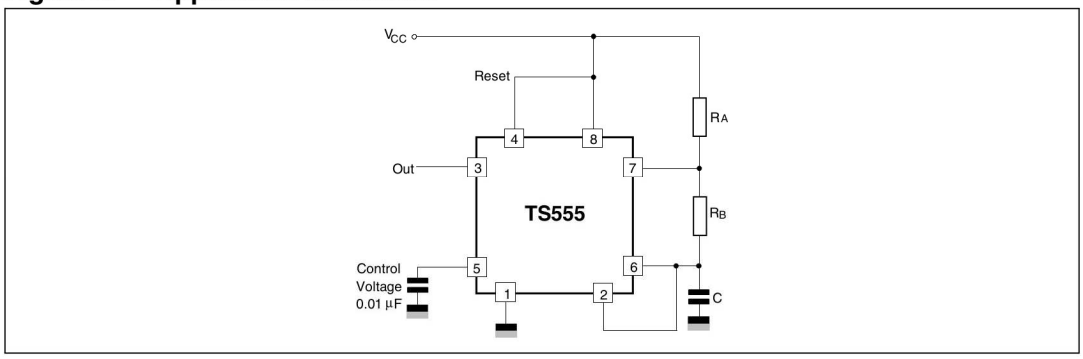


Figure 7 shows actual waveforms generated in this mode of operation.

The charge time (output HIGH) is given by:

$$t1 = 0.693\ (R_A + R_B)\ C$$

The discharge time (output LOW) by:

$$t2 = 0.693\ x\ R_B\ x\ C$$

Thus the total period T is given by:

$$T = t1 + t2 = 0.693\ (R_A + 2R_B)\ C$$

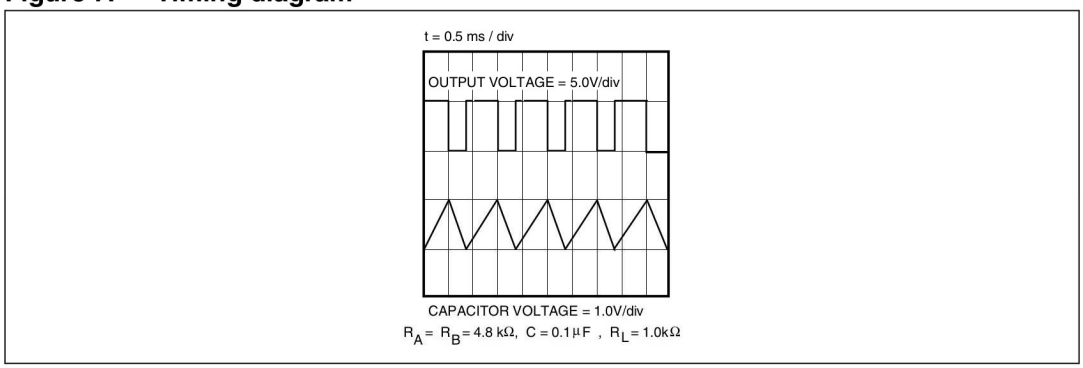
The frequency of oscillation is then:

$$f = \frac{1}{T} = \frac{1.44}{(RA + 2RB)C}$$

The duty cycle is given by:

$$D = \frac{RB}{RA + 2RB}$$

Figure 7. Timing diagram

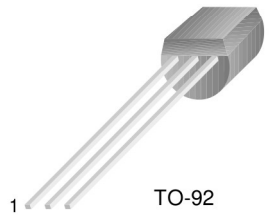


FAIRCHILD
SEMICONDUCTOR TM

BC556/557/558/559/560

Switching and Amplifier

- High Voltage: BC556, V_{CEO}= -65V
- Low Noise: BC559, BC560
- Complement to BC546 ... BC 550



TO-92

1. Collector 2. Base 3. Emitter

PNP Epitaxial Silicon Transistor

Absolute Maximum Ratings T_a=25°C unless otherwise noted

Symbol	Parameter	Value	Units
V_{CBO}	Collector-Base Capacitance		
	: BC556	-80	V
	: BC557/560	-50	V
	: BC558/559	-30	V
V_{CEO}	Collector-Emitter Voltage		
	: BC556	-65	V
	: BC557/560	-45	V
	: BC558/559	-30	V
V_{EBO}	Emitter-Base Voltage	-5	V
I_C	Collector Current (DC)	-100	mA
P_C	Collector Dissipation	500	mW
T_J	Junction Temperature	150	°C
T_{STG}	Storage Temperature	-65 ~ 150	°C

Electrical Characteristics T_a=25°C unless otherwise noted

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Units
I_{CBO}	Collector Cut-off Current	V_{CB}= -30V, I_E=0			-15	nA
h_{FE}	DC Current Gain	V_{CE}= -5V, I_C=2mA	110		800	
V_{CE} (sat)	Collector-Emitter Saturation Voltage	I_C= -10mA, I_B= -0.5mA		-90	-300	mV
		I_C= -100mA, I_B= -5mA		-250	-650	mV
V_{BE} (sat)	Collector-Base Saturation Voltage	I_C= -10mA, I_B= -0.5mA		-700		mV
		I_C= -100mA, I_B= -5mA		-900		mV
V_{BE} (on)	Base-Emitter On Voltage	V_{CE}= -5V, I_C= -2mA	-600	-660	-750	mV
		V_{CE}= -5V, I_C= -10mA			-800	mV
f_T	Current Gain Bandwidth Product	V_{CE}= -5V, I_C= -10mA, f=10MHz		150		MHz
C_{ob}	Output Capacitance	V_{CB}= -10V, I_E=0, f=1MHz			6	pF
NF	Noise Figure : BC556/557/558	V_{CE}= -5V, I_C= -200µA		2	10	dB
	: BC559/560	f=1KHz, R_G=2KΩ		1	4	dB
	: BC559	V_{CE}= -5V, I_C= -200µA		1.2	4	dB
	: BC560	R_G=2KΩ, f=30~15000MHz		1.2	2	dB

h_{FE} Classification

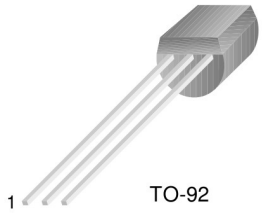
Classification	A	B	C
h_{FE}	110 ~ 220	200 ~ 450	420 ~ 800

FAIRCHILD
SEMICONDUCTOR TM

BC546/547/548/549/550

Switching and Amplifier

- High Voltage: BC546, V_{CEO}=65V
- Low Noise: BC549, BC550
- Complement to BC556 ... BC560



TO-92

1. Collector 2. Base 3. Emitter

NPN Epitaxial Silicon Transistor

Absolute Maximum Ratings T_a=25°C unless otherwise noted

Symbol	Parameter	Value	Units
V_{CBO}	Collector-Base Voltage : BC546	80	V
	: BC547/550	50	V
	: BC548/549	30	V
V_{CEO}	Collector-Emitter Voltage : BC546	65	V
	: BC547/550	45	V
	: BC548/549	30	V
V_{EBO}	Emitter-Base Voltage : BC546/547	6	V
	: BC548/549/550	5	V
I_C	Collector Current (DC)	100	mA
P_C	Collector Dissipation	500	mW
T_J	Junction Temperature	150	°C
T_{STG}	Storage Temperature	-65 ~ 150	°C

Electrical Characteristics T_a=25°C unless otherwise noted

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Units
I_{CBO}	Collector Cut-off Current	V_{CB}=30V, I_E=0			15	nA
h_{FE}	DC Current Gain	V_{CE}=5V, I_C=2mA	110		800	
V_{CE} (sat)	Collector-Emitter Saturation Voltage	I_C=10mA, I_B=0.5mA		90	250	mV
		I_C=100mA, I_B=5mA		200	600	mV
V_{BE} (sat)	Base-Emitter Saturation Voltage	I_C=10mA, I_B=0.5mA		700		mV
		I_C=100mA, I_B=5mA		900		mV
V_{BE} (on)	Base-Emitter On Voltage	V_{CE}=5V, I_C=2mA	580	660	700	mV
		V_{CE}=5V, I_C=10mA			720	mV
f_T	Current Gain Bandwidth Product	V_{CE}=5V, I_C=10mA, f=100MHz		300		MHz
C_{ob}	Output Capacitance	V_{CB}=10V, I_E=0, f=1MHz		3.5	6	pF
C_{ib}	Input Capacitance	V_{EB}=0.5V, I_C=0, f=1MHz		9		pF
NF	Noise Figure : BC546/547/548	V_{CE}=5V, I_C=200µA		2	10	dB
	: BC549/550	f=1KHz, R_G=2KΩ		1.2	4	dB
	: BC549	V_{CE}=5V, I_C=200µA		1.4	4	dB
	: BC550	R_G=2KΩ, f=30~15000MHz		1.4	3	dB

h_{FE} Classification

Classification	A	B	C
h_{FE}	110 ~ 220	200 ~ 450	420 ~ 800